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The following Papers were read :—

- I. "Further Note on the Spectrum of Silicium." By Sir J. NORMAN LOCKYER, K.C.B., F.R.S.
- II. "On Solar Changes of Temperature and Variations in Rainfall in the Region surrounding the Indian Ocean." By Sir J. NORMAN LOCKYER, K.C.B., F.R.S., and Dr. W. J. S. LOCKYER.
- III. "On the Restoration of Co-ordinated Movements after Nerve-crossing, with Interchange of Function of the Cerebral Cortical Centres." By Dr. ROBERT KENNEDY. Communicated by Professor MCKENDRICK, F.R.S.

"Further Note on the Spectrum of Silicium." By Sir NORMAN LOCKYER, K.C.B., F.R.S. Received October 26,—Read November 22, 1900.

In a previous note* I gave an account of some observations on the spectrum of silicium, and showed the relation which exists between the various groups of silicium lines and certain lines prominent in the spectra of some of the hottest stars.

Further photographs have recently been obtained (with a 3-inch Cooke spectrograph) of the spectrum of silicium bromide in a capillary vacuum tube, and of the spark spectrum between two poles of metallic silicium which were kindly sent to me by Sir William Crookes. In each case the large Spottiswoode coil and plate condenser were used. The spectra extend from about λ 3850 to D, and occupy a length of about 7 inches between those limits. Although all the silicium lines are

* 'Roy. Soc. Proc.,' vol. 65, p. 449.

Comparison Table of Silicon Lines and their Behaviour in Stellar Spectra.

Lockyer.			Exner and Haschek. (Spark.)		Eder and Valenta. (Spark.)		Intensities in stellar spectra. Max. = 10.			
λ .	Intensity. Max. = 10.		λ .	Intensity. Max. = 6.	λ .	Intensity. Max. = 10.	α Cygni.	β Orionis.	γ Orionis.	ϵ Orionis.
	Vacuum tube.	Spark.								
3853.9	< 1	1	..	1	3854.0	1	3-4	3	1	
3856.1	5	6	..	1	3856.20	3	6	5	1	
3862.7	4	4	..	5	3862.75	3	6	5	1	
3905.8	3	10	10	1	3905.80	3	4			
4030.0	1	1	..	5						
4089.1	10	2	..	1	..	..	..	..	1	8
4096.9	2	1	..	2	..	..	..	..	..	4
4103.2	2	3	4	..	4103.2	..				
4116.4	6	< 1	..	1	4103.7	1				
4128.1	10	10	2	..	..	..	5-6	5	..	6
4131.1	10	10	2	5	4128.2	4	5-6	5	1	1
4552.8	10	8	..	6	4131.0	4	< 1	1	1	1
4568.0	8	5	..	3	..	..	< 1	< 1	4	4
4574.9*	5	3	..	1	4567.95	..	< 1	< 1	3	3
				1	4574.9	..	< 1	< 1	2	2
5012	5	6	< 1	1	4704.20	1				
5037	10	10	1							

* Previously given as 4575.3. Re-measurement shows this to be an error.

common to the two spectra, the relative intensities of the lines differ greatly.

These later photographs show all the lines enumerated in my former communication, with the addition of several fainter lines and a strong double in the green, the latter falling outside the region previously investigated.

Lines in the spark spectrum of silicium have been recorded by Eder and Valenta* and by Exner and Haschek†. A comparison of these with the lines photographed at Kensington is given in the following table.

Better photographs of the spectra of the type stars have been recently obtained, and we are now in a more satisfactory position to trace the various silicium lines through successive stages of stellar temperature. The lines in the spectra of α Cygni, β Orionis, γ Orionis, and ϵ Orionis which correspond with lines of silicium are indicated in the table by their intensities.

In my former note the lines were divided into three sets, A, B, C, and the behaviour of the different sets in terrestrial and celestial spectra was described. The groupings were then made, roughly speaking, in order of wave-length. For my present purpose, it is important to divide them according to the conditions under which they become prominent lines; this only involves the changing of the order of the groups, and involves no interchange of any of the lines from one group to another. Reference was also made previously to a line at λ 3905.8 special to the arc, but as this is not an enhanced line it was not included in any of the sets A, B, C. Hence, I now add another group consisting of lines most prominent in the arc spectrum. The lines constituting the various groups will then be as given below, arranged in order of ascending temperature, Group I being the lowest :—

Group IV	$\left\{ \begin{array}{l} 4089.1 \\ 4096.9 \\ 4116.4 \end{array} \right.$	Set B of previous note.		
Group III	$\left\{ \begin{array}{l} 4552.8 \\ 4568.0 \\ 4574.9 \end{array} \right.$	Set C	“	“
Group II	$\left\{ \begin{array}{l} 3853.9 \\ 3856.1 \\ 3862.7 \\ 4128.1 \\ 4131.1 \\ 5042 \\ 5057 \end{array} \right.$	Set A	“	“
Group I	$\left\{ \begin{array}{l} 3905.8 \\ 4103.2 \end{array} \right.$			

* ‘Sitz. Kais. Akad. der Wiss. Wien,’ vol. 107, p. 41.

† ‘Ast. Phys. Jour.,’ vol. 12, p. 48.

The lines in Group I, although appearing in the spark spectrum, are stronger in that of the arc, and therefore cannot be classed as enhanced lines. They are both given by Rowland in his "Table of Solar Wavelengths" as being coincident with lines in the Fraunhofer spectrum, and may be considered as the lines of silicium which make their appearance at the lowest of the temperatures we are now considering.

It will be seen that only the stronger line of the two is represented in the spectra of the stars included in the table, and that only in α Cygni, which has been placed lowest in order of ascending temperature among those referred to from a previous investigation of lines in its spectrum other than those of silicium.

It does not appear to exist at the higher stages of stellar temperature represented by β , γ , or ϵ Orionis. The absence of the other line from the spectrum of α Cygni may be accounted for by its comparative weakness in the silicium arc spectrum. In α Cygni only the very strongest of the arc lines of iron, manganese, &c., are represented, and then only as very weak lines.

The lines in Group II are either absent from the most recent arc spectrum photographed at Kensington or exist there only as weak lines. The members of this group are prominent both in the vacuum tube spark and in the spark between poles of silicium, but are upon the whole more prominent in the latter spectrum. Considering the first five lines in the group, which are the only ones comparable with the Kensington records of stellar spectra, a glance at the table will show that they are at their maximum intensity at the stage of temperature represented by α Cygni, and decline in intensity as we pass to the higher successive stages represented by β , γ , and ϵ Orionis. At the latter stage some of them have disappeared, and the others are on the verge of extinction. With regard to the remaining two lines of this group, those at $\lambda\lambda$ 5042 and 5057, the position of which cannot be estimated more accurately than to the nearest tenth-metre on account of the diffuseness of the lines, it is extremely probable that if better photographs of that region of the spectra of α Cygni and Rigel were available, lines would be found corresponding to these silicium lines. Keeler has recorded* a line in the spectrum of Rigel at λ 5056, and this is probably identical with the silicium line at λ 5057, which is by far the stronger of the pair.

The lines in Group III occur both in the vacuum tube spectrum of silicium bromide and in the spark spectrum. They appear as a well-marked triplet in the latter, but not nearly so prominently as in the former.

They first make their appearance in stellar spectra in α Cygni, where, however, they can only just be traced. They are a little stronger in

* 'Ast. and Ast. Phys.,' 1894, vol. 13, p. 489.

β Orionis, and are most prominent in γ and ϵ Orionis, in which two spectra they are of about equal intensity.

The lines in Group IV have never been seen in the spark spectrum of silicium when small coil and small jar capacity are used, but with the spark given by the Spottiswoode coil and plate condenser they appear as weak lines. They are not, like the members of Groups II and III, seen in the spectrum from the bulb when a vacuum tube is used, but in that given by the capillary the strongest ones are very prominent, and vie in intensity with the lines of Group III.

None of them appear in stellar spectra until the level of temperature represented by γ Orionis, and in the spectrum of that star only the strongest of the three is with certainty present. At the ϵ Orionis stage, however, they have developed enormously in intensity, and are amongst the most prominent lines in the spectrum.

The identity of some of the silicium lines—in particular those constituting Group III—with lines in stellar spectra was subsequently but independently confirmed, and the results published,* by Mr. Lunt, Assistant at the Royal Observatory, Cape of Good Hope.

The star the spectrum of which he chiefly considered was β Crucis, similar to that of γ Orionis, the type star in the Kensington classification.

The only enhanced line common to the Kensington and Exner and Haschek's lists, which does not appear to be represented in stellar spectra, is that at λ 4030.0. It is only a weak line in the spark spectrum, and may possibly be due to an impurity, though it has not yet been traced to any other origin. In the Kensington photograph it is a sharply-defined line, and unlike the other silicium lines in appearance. Exner and Haschek, however, record it as a very diffuse line.

Of the four additional lines given by Exner and Haschek at $\lambda\lambda$ 3883.46, 4021.0, 4103.7, and 4764.20, none appear in any of the Kensington photographs, nor are they represented in the spectra of any of the stars included in the discussion. With these facts in view, it would appear extremely doubtful whether they are really due to silicium.

In a former paper "On the Chemical Classification of the Stars,"† I gave the chemical definition of the various groups. At that time only the stronger lines of silicium included in Group II were known and traced through the stellar genera.

We are now in a position to revise the chemical definitions, interpolating the various groups of silicium lines as they appear in the stellar groups.

* 'Astrophys. Jour.,' vol. 11, p. 262.

† 'Roy. Soc. Proc.,' vol. 65, p. 186.

DEFINITIONS OF STELLAR GENERA.

Argonian.

Predominant.—Hydrogen and proto-hydrogen.

Fainter.—Helium, unknown gas (λ 4451, 4457), proto-magnesium, proto-calcium, asterium.

Alnitamian.

Predominant.—Hydrogen, helium, unknown gas (4649.2), silicium (IV).

Fainter.—Asterium, silicium (III), proto-hydrogen, proto-magnesium, proto-calcium, oxygen, nitrogen, carbon, silicium (II).

Crucian.

Predominant.—Hydrogen, helium, asterium, oxygen, nitrogen, carbon.

Fainter.—Proto-magnesium, proto-calcium, silicium (III), unknown gas (λ 4649.2), silicium (II), silicium (IV).

Achernian.

Same as Crucian.

Taurian.

Predominant.—Hydrogen, helium, proto-magnesium, asterium.

Fainter.—Proto-calcium, silicium (II), proto-iron, proto-titanium, proto-chromium, nitrogen, carbon, oxygen.

Algolian.

Predominant.—Hydrogen, proto-magnesium, proto-calcium, helium, silicium (II).

Fainter.—Proto-iron, asterium, carbon, proto-titanium, proto-manganese, proto-nickel.

Rigelian.

Predominant.—Hydrogen, proto-calcium, proto-magnesium, helium, silicium (II).

Fainter.—Asterium, proto-iron, carbon, nitrogen, proto-titanium, proto-chromium, oxygen, silicium (III).

Markabian.

Predominant.—Hydrogen, proto-calcium, proto-magnesium, silicium (II).

Fainter.—Proto-iron, helium, asterium, proto-titanium, proto-manganese, proto-nickel, proto-chromium.

Cygnian.

Predominant.—Hydrogen, proto-calcium, proto-magnesium, proto-iron, silicium (II), proto-titanium, proto-chromium.

Fainter.—Proto-nickel, silicium (I), proto-vanadium, proto-manganese, proto-strontium, iron (arc), helium, silicium (III), asterium.

Sirian.

Predominant.—Hydrogen, proto-calcium, proto-magnesium, proto-iron, silicium (II).

Fainter.—The lines of the other proto-metals and the arc lines of iron, calcium, manganese, silicium (I).

Proto-metallic lines relatively thick, hydrogen relatively thin.

Proto-metallic lines relatively thin, hydrogen relatively thick.

<p><i>Polarian.</i></p> <p><i>Predominant.</i> — Proto-calcium, proto-titanium, hydrogen, proto-magnesium, proto-iron, and arc lines of calcium, iron, manganese, silicium (I).</p> <p><i>Fainter.</i>—The other proto-metals and metals occurring in the Sirian genus.</p>	<p><i>Procyonian.</i></p> <p>Same as Polarian.</p>
<p><i>Aldebarian.</i></p> <p><i>Predominant.</i>—Proto-calcium, are lines of iron, calcium, manganese, proto-strontium, hydrogen, silicium (I).</p> <p><i>Fainter.</i>—Proto-iron and proto-titanium.</p>	<p><i>Arcturian.</i></p> <p>Same as Aldebarian.</p>
<p><i>Antarian.</i></p> <p><i>Predominant.</i>—Flutings of manganese.</p> <p><i>Fainter.</i>—Arc lines of metallic elements.</p>	<p><i>Piscian.</i></p> <p><i>Predominant.</i>—Flutings of carbon.</p> <p><i>Fainter.</i>—Arc lines of metallic elements.</p>

It will be seen that the conclusions arrived at in the former part of the paper as to the different conditions under which the different groups of silicium lines become prominent verify the order in which the stars were placed on a scale of ascending temperatures. Thus those stars in which Group I occurs prominently are at the bottom, those in which Groups II and III predominate occupy intermediate positions, and those in which the lines of Group IV are a special feature appear high up in the classification.

The photographs of the silicium spectra were taken by Mr. Butler. Their discussion has devolved upon Mr. Baxandall, who has also traced the silicium lines through the stellar spectra, and assisted in the preparation of the paper.

“On Solar Changes of Temperature and Variations in Rainfall in the Region surrounding the Indian Ocean.” By Sir NORMAN LOCKYER, K.C.B., F.R.S., and W. J. S. LOCKYER, M.A. (Camb.), Ph.D. (Gött.). Received October 26,—Read November 22, 1900.

The fact that the abnormal behaviour of the widened lines in the spectra of sunspots since 1894 had been accompanied by irregularities in the rainfall of India suggested the study and correlation of various series of facts which might be expected to throw light upon the subject.